UNIVERSITY OF SASKATCHEWAN
College of Engineering
AB E 312.3 Final Exam

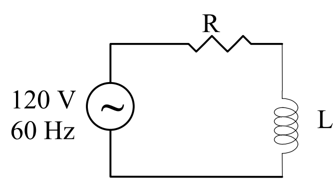
TIME: 3 hours Closed book Calculators Allowed ***MARKS*****:** Total = 100 Dec. 18, 2000

(20) **1.** Define the following:

1) lag
2) relative permeability
3) Lenz's Law
4) torque
5) normally closed
6) commutator
7) equipment grounding
8) dual voltage motor
9) cumulative compound DC motor
10) duty cycle

(4) **2.** Describe the factors that affect the amount of voltage that can be induced in a moving conductor.

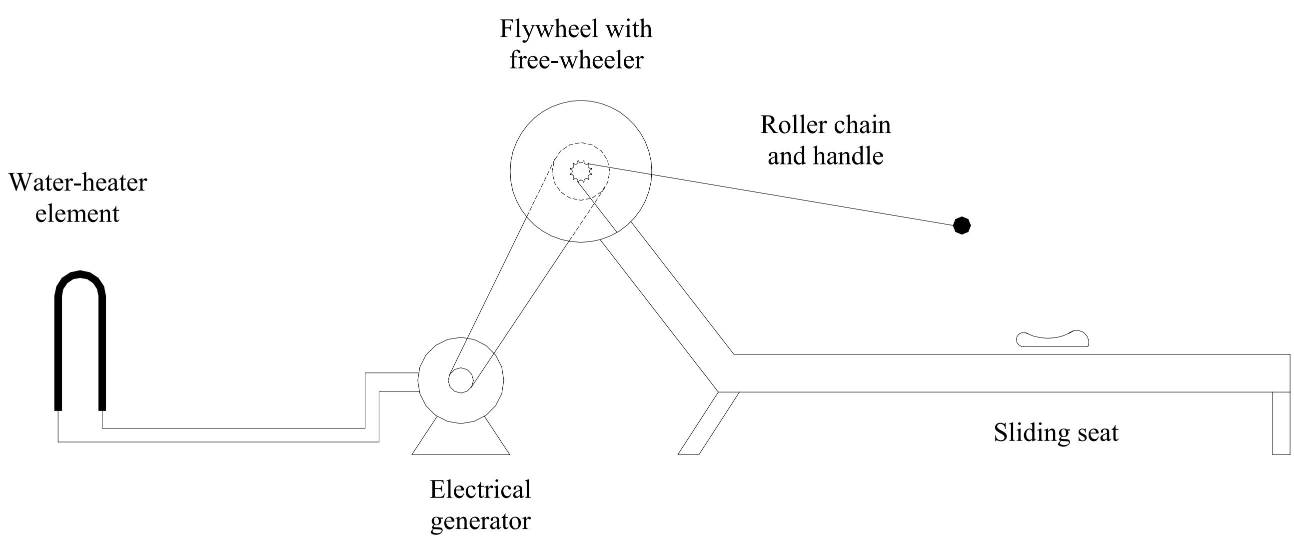
(7) **3.** A single-phase AC motor has a coil resistance of 20 Ω and the inductance under typical operating conditions is 0.06 H. The supply voltage is 120 V at 60 Hz.



a). What is the power factor under these conditions?
b). What capacitance would be required, in parallel with the coil to develop a power factor of 0.95 under the same operating conditions?

(3) **4.** A modern stationary rowing machine is often called an ergometer. The ergometer consists of a seat (on which the athlete sits) that rolls on a rail. A handle, connected to a roller chain simulates the force of an oar. The roller chain drives a free-wheeler (similar to the free wheeler on the rear wheel of a bicycle), which in turn drives a fan. Variable resistance (changing the effort required by the athlete) is achieved by restricting the airflow from the fan. An exercise club has modified their ergometers. The fan has been removed and the free-wheeler is connected to an electrical generator, through a flywheel. The energy from the electrical generator is transferred to elements that are being used to heat water for the swimming pool.

During a single workout, an athlete burns 250 kilo-calories, but only 50% of the energy is transferred to the electrical generator. The efficiency in transferring the electrical energy to the water (in the form of heat) is 85% and the efficiency of the electrical generator is 70%.



a). How much heat energy was transferred to the water, during the single workout?
b). What was the average power delivered to the generator, if the athlete worked out for 40 minutes, during the session?

(4) **5.** Describe how a bi-metallic strip can be used to provide overcurrent protection in a circuit.

(6) **6.** Using a circuit diagram, show how and why a starting resistor is used to start a shunt DC motor.

(4) **7.** How does changing a variable resistance in series with the field windings on a shunt DC motor affect rotational speed and why?

(4) **8.** How and why does changing the source frequency affect the rotational shaft speed of an induction motor?

(4) **9.** What are four design considerations that you would consider regarding the ambient environment when selecting a motor?

(6) **10.** A transformer at a remote field site supplies only one service panel with the following loads attached:

i) a water pump that draws 15 Amps at 240 Volts
ii) a 240 Volt, 2000 Watt electric water heater
iii) a 120 Volt, 150 Watt high intensity discharge mercury vapour yard light.

a). Calculate the current flowing on each line connected to the transformer if all loads were running at the same time.
b). How much would it cost to run the water heater and the light continuously for one day if the cost of energy is \$0.08 per kilowatt·hour?
c). If the wire to the pump has a resistance of 0.6 ohms, then how much power is dissipated as heat in the wire when the pump is running continuously?

(4) **11.** How is overcurrent and low voltage protection incorporated into a magnetic starter?

(3) **12.** A specially built 460 Volt single phase pump motor is located 50 m from the 460/230 volt service panel. If the motor draws 45 Amps at full load, what is the minimum conductor size to maintain less than a 2% voltage drop in the copper wire? (Tables attached at end of exam).

(4) **13.** Why is a starting circuit or mechanism necessary for a single phase AC induction motor?

(2) **14.** What is the purpose of the centrifugal switch in a single-phase capacitor start induction run AC motor?

(3) **15.** A copper NMWU-60 cable is to supply an industrial 24 kilowatt heater on a branch circuit. The heater requires only 240 Volts to operate.
a) Using tables attached at the end, what is the minimum conductor size required?
b) How many insulated conductors are required?
c) How many poles will there be on the circuit breaker?

(4) **17.** Sketch a circuit diagram for a 240 Volt 500 Watt switched light powered from a 120/240 Volt service panel. Describe any differences from a 120 Volt switched light circuit.

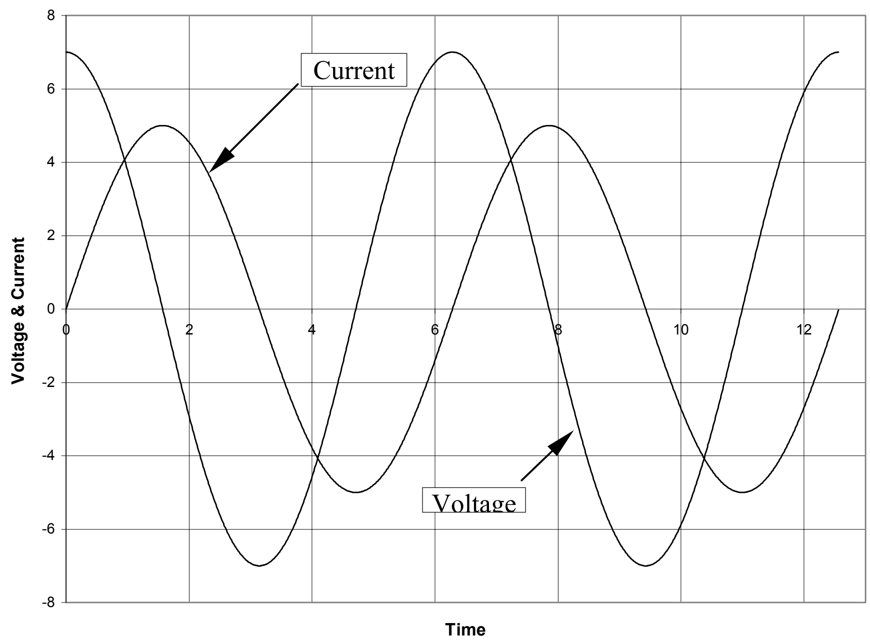
(4) **18.** Why is starting current higher than running current for an induction motor?

(4) **19.** Why does changing the number of field poles in a synchronous motor change the rotational speed of the shaft?

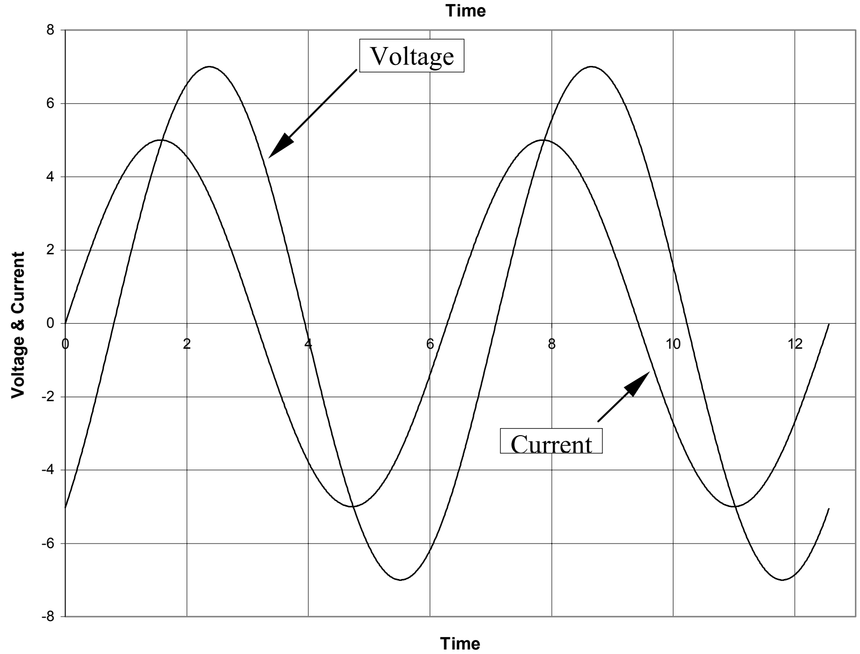
(4) **20.** During your nightshift as plant operations manager, a conveyor belt stops working and shuts down your entire operation. Upon investigation, you find that two fuses have blown in the circuit to the three-phase motor that drives the conveyor. Describe your troubleshooting approach to determine what is required to get the plant running again.

(6) **21.** The following figures are traces of voltage and current from an oscilloscope display. For each figure, indicate whether the load is resistive, capacitive, inductive or a combination of these. Explain your reasoning for each case.

a)



b)



Selected Formulae and Tables

$V = IZ$		$R_t = R_i\,(1+\alpha\Delta T)$
$V_{RMS} = V_{peak} / 1.414$		$R_t = R_1 + R_2 + ...$
$1/R_t = 1/R_1 + 1/R_2 + ...$		$Z_c = 1 / CS$
$Z_L = LS$	$E_P/E_S = N_P/N_S$	$HP = 2\pi FLN / 33000$
$L = N^2/R$	$H = Ni/l$	$R = l/\mu A$
$\phi = \mu NiA/l$		Delta: $V_L = V_p$ & $I_p = I_L/1.732$
Wye: $I_L = I_p$ & $V_p = V_L/1.732$		$P = 3\ V_P I_P \cos\phi$
$P = 1.732\ V_L I_L \cos\phi$		$s = 120f/P$
$C^2 = A^2 + B^2$		$\tan\theta = opp / adj$
$\sin\theta = opp / hyp$		$\cos\theta = adj / hyp$
$P = VI\cos\phi$	$\cos\phi = True / Apparent$	$R = \vartheta L/A$

Tables 2 and 4 from Canadian Electrical Code

THE END